Appendix E
Performance Limiting Factors Summary Materials and Definitions

CPE Factor Summary Sheet Terms

Plant Type	Brief but specific description of plant type (e.g., conventional with flash mix, flocculation, sedimentation, filtration and chlorine disinfection; or direct filtration with flash mix, flocculation and chlorine disinfection).
Source Water	Brief description of source water (e.g., surface water including name of water body).
Performance Summary	Brief description of plant performance based on performance assessment component of the CPE (i.e., ability of plant to meet optimized performance goals).
Ranking Table	A listing of identified performance limiting factors that directly impact plant performance and reliability.
Rank	Relative ranking of factor based on prioritization of all "A" and "B" rated factors identified during the CPE.
Rating	Rating of factor based on impact on plant performance and reliability: A – Major effect on a long-term repetitive basis B – Moderate effect on a routine basis or major effect on a periodic basis C – Minoreffect
Performance Limiting Factor (Category)	Factor identified from Checklist of Performance Limiting Factors, including factor category (e.g., administration, design, operation, and maintenance).
Notes	Brief listing of reasons each factor was identified (e.g., lack of process control testing, no defined performance goals).

CPE Performance Limiting Factors Summary		
Plant Name/Location:		
CPE Performed By:		
CPE Date:		
Plant Type:		
Source Water:		
Performance Summary:		
Ranking Table		
Rank	**Rating**	**Performance Limiting Factor (Category)**

Rating Description

A — Major effect on long-term repetitive basis.

B — Moderate effect on a routine basis or major effect on a periodic basis.

C — Minor effect.

Performance Limiting Factors Notes	
Factor	**Notes**
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Checklist of Performance Limiting Factors

A. ADMINISTRATION

1. Plant Administrators
   - a. ☐ Policies _____
   - b. ☐ Familiarity With Plant Needs _____
   - c. ☐ Supervision _____
   - d. ☐ Planning _____
   - e. ☐ Complacency _____
   - f. ☐ Reliability _____
   - g. ☐ Source Water Protection _____
2. Plant Staff
   - a. ☐ Number _____
   - b. ☐ Plant Coverage _____
   - c. ☐ Personnel Turnover _____
   - d. ☐ Compensation _____
   - e. ☐ Work Environment _____
   - f. ☐ Certification _____
3. Financial
   - a. ☐ Operating Ratio _____
   - b. ☐ Coverage Ratio _____
   - c. ☐ Reserves _____

B. DESIGN

1. Source Water Quality
   - a. ☐ Microbial Contamination _____
2. Unit Process Adequacy
   - a. ☐ Intake Structure _____
   - b. ☐ Presedimentation Basin _____
   - c. ☐ Raw Water Pumping _____
   - d. ☐ Flow Measurement _____
   - e. ☐ Chemical Storage and Feed Facilities _____
   - f. ☐ Flash Mix _____
   - g. ☐ Flocculation _____
   - h. ☐ Sedimentation _____
   - i. ☐ Filtration _____
   - j. ☐ Disinfection _____
   - k. ☐ Sludge/Backwash Water Treatment and Disposal _____

3. Plant Operability
   a. ☐ Process Flexibility _____
   b. ☐ Process Controllability _____
   c. ☐ Process Instrumentation/ _____
      Automation _____
   d. ☐ Standby Units for Key _____
      Equipment _____
   e. ☐ Flow Proportioning _____
   f. ☐ Alarm Systems _____
   g. ☐ Alternate Power Source _____
   h. ☐ Laboratory Space and Equipment _____
   i. ☐ Sample Taps _____

C. OPERATION

1. Testing
   a. ☐ Process Control Testing _____
   b. ☐ Representative Sampling _____
2. Process Control
   a. ☐ Time on the Job _____
   b. ☐ Water Treatment Understanding _____
   c. ☐ Application of Concepts and _____
      Testing to Process Control _____
3. Operational Resources
   a. ☐ Training Program _____
   b. ☐ Technical Guidance _____
   c. ☐ Operational Guidelines/Procedures _____

D. MAINTENANCE

1. Maintenance Program
   a. ☐ Preventive _____
   b. ☐ Corrective _____
   c. ☐ Housekeeping _____
2. Maintenance Resources
   a. ☐ Materials and Equipment _____
   b. ☐ Skills or Contract Services _____

Definitions for Assessing Performance Limiting Factors

NOTE: The following list of defined factors is provided to assist the evaluator with identifying performance limitations associated with protection against microbial contaminants in water treatment systems. Performance limiting factors are described below using the following format.

A. CATEGORY
1. Subcategory
a. Factor Name
- **Factor description**
  - ➢ *Example of factor applied to specific plant or utility*

A. Administration

1. Plant Administrators

a. Policies

+ Do existing policies or the lack of policies discourage staff members from making required operation, maintenance, and management decisions to support plant performance and reliability?
  - > Utility administration has not communicated a clear policy to optimize plant performance for public health protection.
  - > Multiple management levels within a utility contribute to unclear communication and lack of responsibility for plant operation and performance.
  - > Cost savings is emphasized by management at the expense of plant performance.
  - > Utility managers do not support reasonable training and certification requests by plant staff.
  - > Administration continues to allow connections to the distribution system without consideration for the capacity of the plant.

b. Familiarity With Plant Needs

+ Do administrators lack first-hand knowledge of plant needs?
  - > The utility administrators do not make plant visits or otherwise communicate with plant staff.
  - > Utility administrators do not request input from plant staff during budget development.

c. Supervision

+ Do management styles, organizational capabilities, budgeting skills, or communication practices at any management level adversely impact the plant to the extent that performance is affected?
  - > A controlling supervision style does not allow the plant staff to contribute to operational decisions.
  - > A plant supervisor's inability to set priorities for staff results in insufficient time allocated for process control.

d. Planning

+ Does the lack of long range planning for facility replacement or alternative source water quantity or quality adversely impact performance?
  - > A utility has approved the connection of new customers to the water system without considering the water demand impacts on plant capacity.
  - > An inadequate capital replacement program results in utilization of outdated equipment that cannot support optimization goals.

e. Complacency
   > Does the presence of consistent, high quality source water result in complacency within the water utility?
      > Due to the existence of consistent, high quality source water, plant staff are not prepared to address unusual water quality conditions.
      > A utility does not have an emergency response plan in place to respond to unusual water quality conditions or events.

f. Reliability
   + Do inadequate facilities or equipment, or the depth of staff capability, present a potential weak link within the water utility to achieve and sustain optimized performance?
      > Outdated filter control valves result in turbidity spikes in the filtered water entering the plant clearwell.
      > Plant staff capability to respond to unusual water quality conditions exists with only the laboratory supervisor.

g. Source Water Protection
   + Does the water utility lack an active source water protection program?
      > The absence of a source water protection program has resulted in the failure to identify and eliminate the discharge of failed septic tanks into the utility's source water lake.
      > Utility management has not evaluated the impact of potential contamination sources on water quality within their existing watershed.

2. Plant Staff
   a. Number
      + Does a limited number of people employed have a detrimental effect on plant operations or maintenance?
         > Plant staff are responsible for operation and maintenance of the plant as well as distribution system and meter reading, limiting the time available for process control testing and process adjustments.

   b. Plant Coverage
      + Does the lack of plant coverage result in inadequate time to complete necessary operational activities? (Note: This factor could have significant impact if no alarm/shutdown capability exists - see design factors).
         > Staff are not present at the plant during evenings, weekends, or holidays to make appropriate plant and process control adjustments.
         > Staff are not available to respond to changing source water quality characteristics.

   c. Personnel Turnover
      + Does high personnel turnover cause operation and maintenance problems that affect process performance or reliability?
         > The lack of support for plant needs results in high operator turnover and, subsequently, inconsistent operating procedures and low staff morale.

   d. Compensation
      + Does a low pay scale or benefit package discourage more highly qualified persons from applying for operator positions or cause operators to leave after they are trained?
         > The current pay scale does not attract personnel with sufficient qualifications to support plant process control and testing needs.

   e. Work Environment
      + Does a poor work environment create a condition for "sloppy work habits" and lower operator morale?
         > A small, noisy work space is not conducive for the recording and development of plant data.

f. Certification

+ Does the lack of certified personnel result in poor O & M decisions?

> The lack of certification hinders the staff's ability to make proper process control adjustments.

3. Financial

a. Operating Ratio

+ Does the utility have inadequate revenues to cover operation, maintenance, and replacement of necessary equipment (i.e., operating ratio less than 1.0)?

> The current utility rate structure does not provide adequate funding and limits expenditures necessary to pursue optimized performance (e.g., equipment replacement, chemical purchases, spare parts).

b. Coverage Ratio

+ Does the utility have inadequate net operating profit to cover debt service requirements (i.e., coverage ratio less than 1.25)?

> The magnitude of a utility's debt service has severely impacted expenditures on necessary plant equipment and supplies.

c. Reserves

+ Does the utility have inadequate reserves to cover unexpected expenses or future facility replacement?

> A utility has a 40-year-old water treatment plant requiring significant modifications; however, no reserve account has been established to fund these needed capital expenditures.

B. Design

1. Source Water Quality

a. Microbial Contamination

+ Does the presence of microbial contamination sources in close proximity to the water treatment plant intake impact the plant's ability to provide an adequate treatment barrier?

> A water treatment plant intake is located downstream of a major wastewater treatment plant discharge and is subject to a high percentage of this flow during drought periods.

2. Unit Process Adequacy

a. Intake Structure

+ Does the design of the intake structure result in excessive clogging of screens, build-up of silt, or passage of material that affects plant equipment?

> The location of an intake structure on the outside bank of the river causes excessive collection of debris, resulting in plugging of the plant flow meter and static mixer.

> The design of a reservoir intake structure does not include flexibility to draw water at varying levels to minimize algae concentration.

b. Presedimentation Basin

+ Does the design of an existing presedimentation basin or the lack of a presedimentation basin contribute to degraded plant performance?

> The lack of flexibility with a presedimentation basin (i.e., number of basins, size, bypass) causes excessive algae growth, impacting plant performance.

> A conventional plant treating water directly from a "flashy" stream experiences performance problems during high turbidity events.

c. Raw Water Pumping

+ Does the use of constant speed pumps cause undesirable hydraulic loading on downstream unit processes?

> The on-off cycle associated with raw water pump operation at a plant results in turbidity spikes in the Sedimentation basin and filters.

d. Flow Measurement

+ Does the lack of flow measurement devices or their accuracy limit plant control or impact process control adjustments?

> The flow measurement device in a plant is not accurate, resulting in inconsistent flow measurement records and the inability to pace chemical feed rates according to flow.

e. Chemical Storage and Feed Facilities

+ Do inadequate chemical storage and feed facilities limit process needs in a plant?

> Inadequate chemical storage facilities exist at a plant, resulting in excessive chemical handling and deliveries.

> Capability does not exist to measure and adjust the coagulant and flocculant feed rates.

f. Flash Mix

+ Does inadequate mixing result in excessive chemical use or insufficient coagulation to the extent that it impacts plant performance?

> A static mixer does not provide effective chemical mixing throughout the entire operating flow range of the plant.

> Absence of a flash mixer results in less than optimal chemical addition and insufficient coagulation.

g. Flocculation

+ Does a lack of flocculation time, inadequate equipment, or lack of multiple flocculation stages result in poor floc formation and degrade plant performance?

> A direct filtration plant, treating cold water and utilizing a flocculation basin with short detention time and hydraulic mixing, does not create adequate floc for filtration.

h. Sedimentation

+ Does the sedimentation basin configuration or equipment cause inadequate solids removal that negatively impacts filter performance?

> The inlet and outlet configurations of the sedimentation basins cause short-circuiting, resulting in poor settling and floc carryover to the filters.

> The outlet configuration causes floc break-up, resulting in poor filter performance

> The surface area of the available sedimentation basins is inadequate, resulting in solids loss and inability to meet optimized performance criteria for the process.

i. Filtration

+ Do filter or filter media characteristics limit the filtration process performance?

> The filter loading rate in a plant is excessive, resulting in poor filter performance.

> Either the filter underdrain or support gravel have been damaged to the extent that filter performance is impacted.

+ Do filter rate-of-flow control valves provide a consistent, controlled filtration rate?

> The rate-of-flow control valves produce erratic, inconsistent flow rates that result in turbidity and/or particle spikes.

+ Do inadequate surface wash or backwash facilities limit the ability to clean the filter beds?

> The backwash pumps for a filtration system do not have sufficient capacity to adequately clean the filters during backwash.

> The surface wash units are inadequate to properly clean the filter media.

> Backwash rate is not sufficient to provide proper bed expansion to properly clean the filters.

j. Disinfection

+ Do the disinfection facilities have limitations, such as inadequate detention time, improper mixing, feed rates, proportional feeds, or baffling, that contribute to poor disinfection?

> An unbaffled clearwell does not provide the necessary detention time to meet the Giardia inactivation requirements of the SWTR.

k. Sludge/Backwash Water Treatment and Disposal

+ Do inadequate sludge or backwash water treatment facilities negatively influence plant performance?

> The plant is recycling backwash decant water without adequate treatment.

> The plant is recycling backwash water intermittently with high volume pumps.

> The effluent discharged from a sludge/backwash water storage lagoon does not meet applicable receiving stream permits.

> Inadequate long-term sludge disposal exists at a plant, resulting in reduced cleaning of settling basins and recycle of solids back to the plant.

3. Plant Operability

a. Process Flexibility

+ Does the lack of flexibility to feed chemicals at desired process locations or the lack of flexibility to operate equipment or processes in an optimized mode limit the plant's ability to achieve desired performance goals?

> A plant does not have the flexibility to feed either a flocculant aid to enhance floc development and strength or a filter aid to improve filter performance.

> A plant includes two sedimentation basins that can only be operated in series.

b. Process Controllability

+ Do existing process controls or lack of specific controls limit the adjustment and control of a process over the desired operating range?

> filter backwash control does not allow for the ramping up and down of the flow rate during a backwash event,

> During a filter backwash, the lack of flow control through the plant causes hydraulic surging through the operating filters.

> The level control system located in a filter influent channel causes the filter effluent control valves to overcompensate during flow rate changes in a plant.

> Flows between parallel treatment units are not equal and cannot be controlled.

> The plant influent pumps cannot be easily controlled or adjusted, necessitating automatic start-up/shutdown of raw water pumps.

> Plant flow rate measurement is not adequate to allow accurate control of chemical feed rates.

> Chemical feed rates are not easily changed or are not automatically changed to account for changes in plant flow rate.

c. Process Instrumentation/Automation

+ Does the lack of process instrumentation or automation cause excessive operator time for process control and monitoring?

> A plant does not have continuous recording turbidimeters on each filter, resulting in extensive operator time for sampling.

> The indication of plant flow rate is only located in the pipe gallery, which causes difficulty in coordinating plant operation and control.

> Automatic shutdown/start-up of the plant results in poor unit process performance.

d. Standby Units for Key Equipment

+ Does the lack of standby units for key equipment cause degraded process performance during breakdown or during necessary preventive maintenance activities?

> Only one backwash pump is available to pump water to a backwash supply tank, and the combination of limited supply tank volume and an unreliable pump has caused staff to limit backwashing of filters during peak production periods.

e. Flow Proportioning

+ Does inadequate flow splitting to parallel process units cause individual unit overloads that degrade process performance?

> Influent flow to a plant is hydraulically split to multiple treatment trains, and uneven flow distribution causes overloading of one flocculation/sedimentation train over the others.

f. Alarm Systems

+ Does the absence or inadequacy of an alarm system for critical equipment or processes cause degraded process performance?

> A plant that is not staffed full-time does not have alarm and plant shut-down capability for critical finished water quality parameters (i.e., turbidity, chlorine residual).

g. Alternate Power Source

+ Does the absence of an alternate power source cause reliability problems leading to degraded plant performance?

> A plant has frequent power outages, and resulting plant shutdowns and start-ups cause turbidity spikes in the filtered water.

h. Laboratory Space and Equipment

+ Does the absence of an adequately equipped laboratory limit plant performance?

> A plant does not have an adequate process control laboratory for operators to perform key tests (i.e., turbidity, jar testing).

i. Sample Taps

+ Does the lack of sample taps on process flow streams prevent needed information from being obtained to optimize performance?

> Filter-to-waste piping following plant filters does not include sample taps to measure the turbidity spike following backwash.

> Sludge sample taps are not available on sedimentation basins to allow process control of the sludge draw-off from these units.

C. Operation

1. Testing

a. Process Control Testing

+ Does the absence or wrong type of process control testing cause improper operational control decisions to be made?

> Plant staff do not measure and record raw water pH, alkalinity, and turbidity on a routine basis; consequently, the impact of raw water quality on plant performance cannot be assessed.

> Sedimentation basin effluent turbidity is not measured routinely in a plant.

b. Representative Sampling

+ Do monitoring results inaccurately represent plant performance or are samples collected improperly?

> Plant staff do not record the maximum turbidity spikes that occur during filter operation and following filter backwash events.

> Turbidity sampling is not performed during periods when the reclaim backwash water pump is in operation.

2. Process Control

a. Time on the Job

+ Does staff's short time on the job and associated unfamiliarity with process control and plant needs result in inadequate or improper control adjustments?

> Utility staff, unfamiliar with surface water treatment, were given responsibility to start a new plant; and lack of experience and training contributed to improper coagulation control and poor performance.

b. Water Treatment Understanding

+ Does the operator's lack of basic water treatment understanding contribute to improper operational decisions and poor plant performance or reliability?

> Plant staff do not have sufficient understanding of water treatment processes to make proper equipment or process adjustments.

> Plant staff have limited exposure to water treatment terminology, limiting their ability to interpret infarmation presented in training events or in published information.

c. Application of Concepts and Testing to Process Control

+ Is the staff deficient in the application of their knowledge of water treatment and interpretation of process control testing such that improper process control adjustments are made?

> Plant staff do not perform jar testing to determine appropriate coagulant dosages for different water quality conditions.

> Plant filters are placed back in service following backwash without consideration for effluent turbidity levels.

> Filter to waste valves are available but are not used following filter backwash.

> Plant staff do not calculate chemical dosages on a routine basis.

> Plant staff do not change chemical feed systems lo respond to changes in raw water quality.

> Filters are backwashed based on time in service or headloss rather than on optimized performance goal for turbidity or particle removal.

> Plant staff *bump" filters by increasing the hydraulic loading to see if backwashing is necessary.

> Sedimentation basin performance is controlled by visual observation rather than process control testing.

3. Operational Resources

a. Training Program

+ Does inadequate training result in improper process control decisions by plant staff?

> A training program does not exist for new operators at a plant, resulting in inconsistent operator capabilities.

b. Technical Guidance

+ Does inappropriate information received from a technical resource (e.g., design engineer, equipment representative, regulator, peer) cause improper decisions or priorities to be implemented?

> A technical resource occasionally provides recommendations to the plant staff; however, recommendations are not based on plant-specific studies.

c. Operational Guidelines/Procedures

+ Does the lack of plant-specific operating guidelines and procedures result in inconsistent operational decisions that impact performance?

> The lack of operational procedures has caused inconsistent sampling between operator shifts and has led to improper data interpretation and process control adjustments.

D. Maintenance

1. Maintenance Program

a, Preventive

+ Does the absence or lack of an effective preventive maintenance program cause unnecessary equipment failures or excessive downtime that results in plant performance or reliability problems?

> Preventive maintenance is not performed on plant equipment as recommended by the manufacturer, resulting in premature equipment failures and degraded plant performance.

> A work order system does not exist to identify and correct equipment that is functioning improperly.

b. Corrective

+ Does the lack of corrective maintenance procedures affect the completion of emergency equipment maintenance?

> A priority system does not exist on completion of corrective maintenance activities, resulting in a critical sedimentation basin being out of service for an extended period.

> Inadequate critical spare parts are available at the plant, resulting in equipment downtime.

c. Housekeeoing

+ Does a lack of good housekeeping procedures detract from the professional image of the water treatment plant?

> An unkempt, cluttered working environment in a plant does not support the overall good performance of the facility.

2. Maintenance Resources

a. Materials and Equipment

+ Does the lack of necessary materials and tools delay the response time to correct plant equipment problems?

> Inadequate tool resources at a plant results in increased delays in repairing equipment.

b. Skills or Contract Services

+ Do plant maintenance staff have inadequate skills to correct equipment problems or do the maintenance staff have limited access to contract maintenance services?

> Plant maintenance staff do not have instrumentation and control skills of access to contract services for these skills, resulting in the inability to correct malfunctioning filter rate control valves.